“ISDN Anywhere” Guidelines Document

Purpose

This document has been prepared by the “BRI Anywhere” Working Group of the NIUF.
The purpose is to:

1) provide an overview of the technological challenges facing service providers who are attempting to provide ISDN BRI service in a universal fashion
2) where available provide contact information for vendors who provide equipment which can be used to overcome these problems

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Background

Telephone companies’ network equipment can be grouped into three broad categories: central office switching equipment, transmission systems, and access or local loop equipment. With the introduction of electronic and digital telephone switches and fiber optic communications systems during the last twenty years, the first two categories have dominated the capital expenditures by telephone companies. This is a clear shift from the switching to transmission segment. As a result of these capital programs, the North American network is now has a high deployment of digital switches and digital, fiber optic transmission systems linking these switches together.

This leaves the local loop as the remaining bottleneck to the achievement of an end-to-end digital telecommunications network. Capital expenditures projected by telephone companies are increasingly being focused on upgrading the local loop plant to support the digital goal. This is necessary not only to prepare the network to provide “ISDN Anywhere”, but also to cope with access line growth well above the historical rate of 2% to 3%. US telephone companies overall have added over 7 million access lines in 1996 and another 6.5 million are projected for 1997. Among the main drivers of the growth in access lines is demand for second lines for Internet access and telecommuting. As businesses and consumers discover the limitations of analog modems for these applications, a significant fraction of this demand will be driven in the direction of ISDN BRI and other companion xDSL services.

In the past two decades, most improvements in local access technology have come with the use of digital loop carrier (DLC) systems. These systems take part of the network functionality that historically has been in telephone central office switches and disperses it to remote points outside of the CO. If a telephone is less than approximately three miles from the CO it can be connected directly to the switch via a copper pair. However, once that distance is exceeded, loop electronics are generally needed to reach the subscriber. The most common class of loop electronics are digital loop carrier (DLC) remote terminals. The high-speed link to the DLC can be either fiber optic or copper (T-spans or HDSL). Most telephone companies today build new local access networks using DLCs, and use fiber cables to feed them wherever it is justified by either the density of the lines or maintenance cost savings.

The ultimate goal of telephone companies is to deploy fiber as close to end users as possible, as soon as possible. However, there is no way copper can be phased out of the local access network in the near or foreseeable future. In fact, with overall access line growth of 4% to 6% versus the historical range of 2% to 3%, copper based loops should increase over the next few years. This growth is in spite of aggressive deployment of fiber-based DLC systems. With new technologies such as ISDN coming along to increase the carrying capability of the embedded copper, its life will be extended indefinitely.

Initially, digital loop carrier systems relied on digital multiplexing techniques to increase the capacity of existing copper cables. AT&T's SLC 96 and SLC Series 5 are examples of early generation subscriber loop carrier systems that extended from the CO via T-1 spans in copper cables. DLC systems have since advanced to the point where they are now used routinely with fiber-optic cables. The newest DLC systems are known as "next-generation" DLCs (NGDLC). The Litespan system from DSC Communications and the SLC Series 2000 from Lucent Technologies are examples of NGDLC systems.

Historically, public switched telephone networks have consisted of analog transmission circuits over copper wire from a customer's premises to the telephone company's central office switches. Digital transmission circuits, which permit much greater data capacity, reliability and quality, were typically carried over high bandwidth media, such as fiber optic or coaxial cable. This architecture was first deployed in a telephone carrier's network to interconnect central office switches. While the Public Switched Telephone Network *(*PSTN) backbone has been upgraded with fiber optic cable, telephone companies recognized that it would be extremely expensive, time consuming and labor-intensive to lay fiber optic or coaxial cable directly to their end users. It has also not been clear until recently whether demand for the higher bandwidth services directly to the end users would justify the fiber build-out expense.

In the last few years, telephone companies have begun deploying some fiber facilities to extend their central office switches to high customer density areas through the use of DLC systems. Typically the actual end user connection does not change. Consequently, the "last mile"; i.e., the local subscriber loop though which most telephone services are still being delivered to end users, remains based on twisted copper wire handling low speed, analog transmission.

The last mile's limitations have become more noticeable over the past half decade as demand for higher speed dial-up data service has followed directly the interest in on-line service usage. The copper medium itself is not the bandwidth bottleneck. Rather, it is the PSTN's architecture and switches, which are based on an analog frequency of 4 Khz per channel. When developed many years ago, the PSTN was designed for voice communications only, and a 4 Khz channel was more than sufficient for nearly all voice signals sent over the network. However, when converted to digital signals, without compression, the 4 Khz analog circuit is transported throughout the switching network as 64 Kbps. Therein lies the theoretical limit of analog modem speeds. This limitation is further reduced by 8 of the 64kbs being utilized for signaling purposes in most analog networks.

Additionally, telephone companies must now face the fact that their end-office switches are engineered for a call holding time of approximately 4 to 8 minutes. The explosion of Internet and on-line data traffic, when coupled with flat rate pricing for those services, have increased the average holding time to an estimated 25 to 30 minutes. If not administered properly this can result in overloaded network trunk groups, concentrated traffic in the local switches and markedly increased failed call attempts.

Telephone companies must develop ways to provide high bandwidth digital services over the last mile and to efficiently connect these signals to their switches. ISDN allows the existing copper network to carry much more information, in digital form. DLC's capable of TR-303 configurations and NGDLCs allow this information to be multiplexed into high speed digital signals and these signals to be connected directly into digital switches.

Barriers to ISDN Anywhere

Long Loops

The standard for ISDN Basic Rate Access calls for full-duplex transport of ISDN basic rate signals over a 2-wire, non-loaded copper loop up to 18 kft, regardless of bridged-tap. The line code, 2B1Q, selected for ISDN will provide this range capability. It was originally intended that subscribers beyond 18 kft from the ISDN central office be served from either a remote switching device or a DLC system. As telephone companies move toward full deployment of ISDN services, demands for ISDN services have emerged that are beyond the 18 kft range and that can not be economically served by a DLC or RSU. An example would be an order for ISDN service from a subscriber who is distant from the central office and in an area where there is insufficient demand to justify the placement of a DLC.

To address long loops, products that provide for the transport of individual ISDN basic rate signals, on a pair-by-pair basis, beyond the 18 kft range is available. See Appendix A for vendor contact information.

Shortages of Distribution Cable Pairs

Since about 1980, the telephone companies' outside plant has been designed in accordance with "The Carrier Serving Area Concept". A Carrier Serving Area (CSA) is an area that is or may be served by a DLC. A CSA usually comprises 200 to 600 residential units. All loops within a CSA are non-loaded and are usually designed to be 12 kft or less in physical length. As such, these loops can support conventional voice grade telephone services, digital data services up to 64 kbps and ISDN basic rate services.

Much of the CSA plant designed and built in the 1980s was engineered on a basis of 2 pairs per living unit. Much of it was buried below the ground level. This included the splices between service drops and distribution cable pairs. Therefore, a great deal of the distribution plant that has been constructed since 1980 is essentially "hard-wired" for only 2 pairs per residential unit. The dramatic growth in demand for second main lines, the new demands for ISDN, and the natural attrition of cable pairs over time have combined to create severe shortages of copper pairs within many CSAs. This is equally true for pairs served directly from central offices.

To answer distribution cable shortages, products that multiplex several services on a single pair of wires are needed. See Appendix A for vendor contact information.

Early Generation Digital Loop Carriers

Digital Loop Carrier (DLC) systems were introduced in the early 1970s. They were originally conceived as an economical alternative to individual copper facilities for long feeder routes. As their cost decreased and their capabilities were expanded, DLCs began to be used in urban and suburban areas as well. About 15 to 20% of all subscriber loops in the US are served by DLC systems. Although advanced "Next Generation Digital Loop Carriers" were introduced in the early 1990s, most loops served by DLCs are served by early generation systems such as the AT&T SLC-96, SLC-Series 5, Nortel DMS-1 Urban and similar systems.

The early generation DLC systems were designed to support primarily POTS service. As time passed, additional service interfaces were developed to support most two and four-wire “special services”. With the single exception of Digital Data Service (DDS), all these service interfaces involved converting the voice-band signal from analog to a digital DS0 channel, which occupied one time slot in the T-1 signals connecting the DLC remote terminal to the CO.

The designs of these early generation DLC systems did not anticipate the advent of ISDN, with a requirement for a 160 kbps digital signal channelized as two 64 kbps bearer channels, a 16 kbps data channel and accompanying 16kbps overhead. Although improvisations have been devised for the more numerous DLC systems; e.g. BRITE cards for SLC-96 and SLC-Series 5 systems, many existing DLCs will not support ISDN at all. Even those that do require the assignment of 3 consecutive DS0 channels for each ISDN line, often requiring costly and time consuming plant rearrangements to provision ISDN service. An additional constraint is the small physical space available in many of the cabinets designed to house these DLC systems.

To address early DLC systems, products that can be added to existing DLCs or co-located with them to provision ISDN services from DLC remote cabinets are required. See Appendix A for vendor contact information.

Analog Loop Carriers

Analog carrier systems, both single channel and multichannel, have been available for loop applications since the early 1960s. The single channel systems provide an additional voice channel, often called an “added main line” (AML) by using frequency spectrum above the voice frequency band. These systems were usually used in congested, metropolitan areas to defer new cable or drop installations.

Multichannel analog carrier systems provide four to eight channels on a single cable pair. Unlike single channel systems, no voice frequency channel is provided. Multichannel systems come in either a grouped configuration, where all customer connections are made from a single remote terminal at the end of the carrier line, or in a distributed configuration where customer connections are made at several points along the same carrier line. Multichannel systems have usually been used in low growth areas, typically on long loops in rural areas. The range of multichannel systems can be extended with repeaters, basically analog amplifiers, located at intervals along the carrier line. Repeater spacing is typically about 35 dB.

Analog carrier systems are incapable of delivering ISDN and many other network-based services. Moreover, there are spectrum compatibility problems that will not allow ISDN basic rate services to be delivered in the same cable sheath as analog carriers. These problems have encouraged telephone companies to limit the deployment of new analog carrier systems and to remove existing systems where possible. However, a substantial amount of telephone companies’ distribution plant, much of it in rural areas is designed around multichannel analog carriers. To replace them all would require very large investments in either new copper plant or conventional DLCs.

To address analog carrier systems, a set of direct digital replacement for multi-channel analog carriers is required. See Appendix A for vendor contact information.

Appendix A

Company Contact Information

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Appendix B

Submission Form for Appendix A

COMPANY NAME ______________________________

ADDRESS ______________________________

____

PHONE/FAX ______________________________

WEB SITE ______________________________

E-MAIL ______________________________

CATEGORY *(Check all that apply)*:

____ Long Loops ____ Distribution Cable Shortage

____ Legacy DLCs ____ Analog Carrier Systems

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I give the NIUF (North American ISDN Users' Forum) permission to publish the above information in the completed BRI Anywhere Guidelines document from my company.

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